A Common Research and Development Agenda for Subject Interoperability Services?

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Knowledge Organisation Systems (KOS) – thesauri, classification schemes, taxonomies, ontologies, and similar approaches to vocabulary control – have an important role to play in facilitating the handling of information by subject. Their aim may be simply to retrieve information with particular subject content, or to conduct the more advanced forms of information processing suggested by the semantic web vision[1].

Despite the different means of tackling inter-KOS and inter-lingual interoperability currently in play and the size and complexity of the problem itself, it is both desirable and possible to progress towards subject interoperability across the networked world. The aim of this paper is to suggest that this progress can be done through co-ordinated collaborative effort – by agreeing a model set of requirements for interoperability service design and collectively pursuing a common research and development agenda based on it.

An individual KOS has different strengths and weaknesses when used to describe the subject content of particular types of resource for particular types of user with particular needs (see e.g. Ledsham 1999, and Garrod 2000). It is necessarily the case that different information services deploy different KOS for subject description. This raises inter-KOS interoperability issues for any retrieval facility or semantic web application that must successfully operate across two or more such services.

Tackling these issues – and their extension into the realm of multi-lingual subject-based processing – is a significant focus in terminology research. There has been a good deal of recent work in the area – MACS[2] (Freyre and Naudi (2001), LIMBER (Miller and Matthews, 2001), RENARDUS[3] (Koch, 2001; Heery, 2001), HILT[4] (Nicholson D. and McCulloch E., 2006, Macgregor et al, 2007), KoMoHe[5] (Mayr and Petras, 2008), and STAR[6] (Tudhope et al, 2008) are examples, but see Zeng and Chan (2004) for others.

However, it has been uncoordinated work – at least at an inter-project level – even though there is a good deal of overlap in many of the issues addressed.

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1 *An overview of this can be found in Shadbolt et al, 2006; and Berners-Lee et al, 2001*
2 *MACS Project: https://macs.vub.ac.be/pub/*
3 *RENARDUS Project : http://renardus.sub.uni-goettingen.de/*
4 *HILT Project http://hilt.cdlr.strath.ac.uk/ (funded by JISC (http://www.jisc ac.uk/)and supported by OCLC (http://www.oclc.org/))*
5 *KoMoHe Project http://www.gesis.org/en/research/information_technology/komohe.htm*
6 *STAR Project http//:hypermedia.research.glam.ac.uk/kos/star/*

Terminology Services and Subject Interoperatively Services

As defined here, a subject interoperability service is more than just a terminology service. Vizine-Goetz et al (2004) use the phrase "terminology services" to mean "Web services involving various types of knowledge organization resources, including authority files, subject heading systems, thesauri, Web taxonomies, and classification schemes" and "a Web service that provides mappings from a term in one vocabulary to one or more terms in another vocabulary is an example of a terminology service". By this definition, a terminology service provides data to facilitate subject interoperability.

As used here, a subject interoperability service goes beyond this. In the present paper, a subject interoperability service is taken to be a service that encompasses the use of such terminology services, the crosswalk and other data they supply. It also utilises relevant data and software functions from other sources such as user profiling services, together with a range of user interface handling routines, to transparently facilitate user working across multiple information services using multiple KOS.

At minimum, it would include at least one web service based terminology service. It would also include the user interface routines required to request, receive, and process data from such remote services for the benefit of local users seeking to work across multiple information services using multiple KOS (but there is more to it than this, as will become clear in sections 3 and 4 below).

For the sake of simplicity, the focus in this paper will be on optimising interoperability in multi-KOS subject searching. However, it should also apply in other information handling applications where successful mangement of inter-KOS interoperability is a requirement.

Why a Collaborative Approach and Model Requirements Set for Interoperability?

An examination of the subject interoperability landscape points up three things. First, that the issue is of increasing concern to a wide range of organisations (as the membership of the various projects listed in the aforementioned Zeng and Chan, 2004 will affirm). Second, that the problem is one of significant size and complexity[7]. Third, that it is likely to raise overlapping but varying sets of issues in different community contexts. However, it also entails many elements of common concern for which a collaborative approach is either the best approach, or the only feasible one.

Taken together, these suggest that a move towards a collaborative approach is not only a desirable, but a necessary goal to a successful outcome. The problem is large and difficult to tackle, has potential for collaboration in the growing number of organisations. It probably requires action in a variety of communities using methods developed and tested in those communities (see, for example, Friesen, N. 2002). It also has many common elements where division of labour is both feasible and desirable.

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[7] *A flavour of just how complex can be gleaned if we consider that simple subject retrieval raises a plethora of issues in its own right (see, for example, Spiteri, 1999; Olson, 1994; McCorry, 1991), even in the relatively simple circumstances of one user addressing one retrieval problem in one service. If it is to be effective, a common approach to the problem of subject interoperability must be adaptive to these and similar subject retrieval issues in both single and multiple scheme situations. Nor is it simply a matter of identifying a set of schemes to be made interoperable and using a single approach to solve the interoperability problem for these schemes. Many different approaches to this problem have been developed and applied. Zeng and Chan (2004) identify a number of methods for achieving and improving interoperability, including derivation/modelling, translation/adaptation, direct intellectual mapping, and mapping via a spine. Other potential solutions proposed include automatic or semi-automatic classification (see for example Koch and Vizine-Goetz, 1998; Godby et al, 1999; Ardo, 2004). All will have their own problems and will raise different issues for an effective common approach - see, for example, Doerr, 2001, McCulloch et al, 2005, and Whitehead, 1990 on issues related to the mapping approach.*

Any effective mechanism for implementing, organising, and co-ordinating a collaborative approach requires at least the first and last of the following attributes, and preferably all five:

- A generally accepted perspective on the nature and scope of the problem to be tackled
- Agreement on the problems and issues that need to be addressed if it is to be resolved
- An understanding of why, where, and how these relate to both the problem as a whole and each other
- A basis for reaching agreement on how success and failure should be measured in respect of both the problem itself and its individual elements
- A low-maintenance but effective mechanism to facilitate successful co-ordination of the efforts of a wide range of globally distributed 'players'.

Arguably, a model requirements set provides all five in a way that no other mechanism can. It offers the first four through providing an agreed focus on the needs of an effective service. And it offers the last because it ensures co-ordination of independent and devolved efforts of participating organisations, researchers, and developers. If widely adopted, it has the potential to bring focus and structure to collaborative R&D efforts without requiring the massive investment in time and effort.

A Tentative Model Requirements for Interoperability Service Design

Clearly, a key question in this enterprise is how to ensure that the requirements set is such that it can be applied by most players who will be involved in the collaborative effort. Agreement on a common requirements set is difficult because no one community faces quite the same problem – the mix of services, domains, KOS, languages, users, tasks, and crosswalk approaches can be different in every case.

Of course, the intention is not to propose requirements set that any and every subject interoperability service must adopt. The model is presented only to put forward the suggestion that there is merit in adopting a model requirements set, stimulate discussion on, and to propose a possible initial set.

The intention is to suggest that the set outlined below might be widely applied to the design of subject interoperability services, aim, with beneficial results at both local and global level. Nonetheless, wide adoption of some form of common requirements set is a primary aim.

One way of resolving it is to aim to be *inclusive* – to design a requirements set that *assumes* the need to use work from different domains, with different, often unknown, sets of KOS and markups, different problem sets, different approaches to 'crosswalking', different user types and tasks, and so on. This is the approach adopted here. The upshot is a tentative model requirements set with the seven high level elements shown in the table in Inset 1 below, which envisages a subject interoperability service with the ability to:

- Accurately express a user's subject search in the KOS used by a given information service. This is an obvious requirement[8], and the essence of any subject interoperability service.

[8] *A service can only process a user's search effectively in a given service if it can translate the terms used by the user into the terminology used in the service's KOS. A database consisting purely of preferred and non-preferred terms from standard schemes is unlikely to be successful in matching user terms in every case. McCray (1999) reports that terms entered by users do not tend to match those used in standard medical terminologies. Bates (2002) has noted that the range of vocabulary used by information system users is extremely wide and varied. Buckland (1999) has also reported that a searcher using the term 'coastal pollution' in databases using MeSH or LCSH would have difficulties since neither scheme uses that term for that concept. In a test using a pilot interoperability service, Shiri et al., (2004) found that a database based on preferred and non-preferred terms from a range of KOS matched 4 out of 5 user terms, but even this surprisingly high figure entails a 20% failure rate – less than ideal in an effective interoperability service.*

- Identify other information services in a subject area, their KOS', and related KOS crosswalk services. In many circumstances – for example in many current and recent projects – these may all be known. In the real world, however these are increasingly likely to be partially or wholly unknown. To satisfy a subject query, a subject searcher may need access to services unknown to both the searcher and the information service he or she usually uses.
- Identify a user's subject in relation to some standard scheme[9]. Unless this is known or can be determined, it will be impossible to identify services whose subject coverage is relevant to the user's query and impossible to identify the right terms for that query in a service's KOS.
- Offer a user and task adaptive approach. This is needed to help identify both information services and crosswalk services relevant to a user's search.

Operate effectively whilst encompassing a range of distributed elements. If the service is to be truly inclusive, it must, at minimum, encompass the use of distributed cross-walk services and registries of cross-walk services.

Offer multiple protocol[10] and schema[11] support – in order to ensure that the design can be applied widely across communities and domains using their own preferred protocols and schemas

Offer Machine-to-Machine (M2M) functionality so that the interoperability service can be integrated into local information services in a fashion transparent to users.

Tentative Model Requirements Set ; Ability to:

Accurately express a user's subject search in the KOS used by a given information service	Essence of any subject Interoperability service
Identify other information services in a subject area; their KOS; relevant KOS crosswalk services	Known? Need to discover unknown services growing
Identify a user's subject in relation to some standard scheme (KOS)	Needed to identify relevant I services and KOS terms
Offer a user and task adaptive approach	Possibly needed to identify Info/crosswalk services
Operate effectively whilst encompassing a range of distributed elements	Needed for wide registry/ service/crosswalk coverage
Offer multiple protocol and schema support	Needed to ensure inclusivity of domains & communities
Offer Machine-to-Machine (M2M) functionality	Needed for locally adaptive, user transparent services

Inset 1: Tabulated summary of the requirements set; Ability to:

9 *The subject a user is searching for information on is not always unambiguously evident from the terms he or she uses to search for it. Although terms entered by users of the HILT II pilot in an evaluation exercise were found four times out of five in the HILT database (Shiri et al, 2004), it was commonly true that the term entered identified a range of possible subjects and that further clarification was required from the user via the disambiguation mechanism described in Nicholson et al (2006).*

10 *For example, both SRU/W and Z39.50*

11 *For example, SKOS, ZTHES, MARC mark-ups for terminologies data*

The Model in Practice

The reasons for including these various requirements should become clearer through an examination of how a service based on them would work in practice. This is best understood if the account below is used with the diagram in **Inset 2** on the next page. As this illustrates, the assumption is that:

- There are multiple service registries available that 'know' about each other, so any given information service only needs to know about their own 'home' service registry
- There are multiple information services available, recorded in and discoverable via one or more service registries, and classified according to their subject coverage
- There are multiple user and task profile registries available, also recorded in and discoverable via one or more service registries
- There are multiple KOS and KOS 'crosswalk' services available, also recorded in and discoverable via one or more service registries (or possibly terminology registries)
- There are many information services available using many different KOS and access protocols
- The user's start point is usually (but not necessarily) one of these information services
- The users home information service offers the user a facility to cross search other information services appropriate to her subject needs and uses a subject interoperability service (encompassing the whole of the diagram in inset 2) to underpin this service.
- Most of the workings of this service are transparent to the user
- The assumption is that the user starts at one of the information services and needs to search one or more (possibly unknown) others.
- The home service goes through the processess shown in the five boxes along the bottom of the **Inset 2** diagram, using the services registries, user and task profile registries and KOS and KOS crosswalk services shown in the upper half of the diagram as necessary (see description in **Inset 3**).

Inset 3

In a fully implemented system, the user's home information service would go through the following steps:

- Use local information or information from user and task registries (possibly discovered via service registries) to gather relevant information on the context as indicated by the user's profile and her task
- Identify the user's subject in relation to some standard scheme (e.g via user selected hits in a local database or by finding it in the preferred or non-preferred terms of a standard scheme through a KOS service identified via a service registry)
- Identify (1) other information services relevant to the user's subject, user profile, and task, (2) Their KOS, (3) KOS crosswalk services appropriate to each individual KOS, either via local information, or service registries
- Select the best information services to search either from user and task profile or user interaction
- Obtain interoperability data for each relevant KOS via KOS and KOS crosswalk services
- Use the data to facilitate user search of appropriate services, sometimes transparently, but often interactively
- Use the data to provide other useful user services such as results ranking (McCulloch and Macgregor, 2008)

A Feasible Proposition?

Are services based on the model requirements set known to be a feasible proposition? At a basic level, yes, they are. For example, Phases III and IVof HILT built pilot subject interoperability services that included working mechanisms that identified a user's subject, used it to identify information services and their KOS via a service registry. Also, they drew crosswalk data on a range of

KOS from a central terminology server, and used it to facilitate user searches using terms from the KOS appropriate to a given service.

HILT has not yet implemented user and task profiling, but there is no reason to suppose that there are insurmountable technical barriers to implementing these. It has not implemented distributed KOS crosswalk services, but the use of a service registry to identify information services by subject proved the mechanism. The project is working on a pilot that will illustrate distributed crosswalks in action using pilot terminology services set up by OCLC.

As is clear from the examples of required R&D work listed in Section 6 below, a good deal of work is still required on detailed workability. However, a service based on the requirements set appears to be workable at a basic level.

A Focus for Collaborative Research and Development Work?

As will be evident, none of the requirements suggested above is especially new. The set is important not because it is innovative but because it offers the possibility of co-ordinating and directing future work. The requirements set just described suggests a need for research and development in a wide variety of areas. Their possibilities are listed in Inset 4 and Inset 5 below being illustrative and selective rather than necessarily

Inset 4

Developmental work (alternative mechanisms for/approaches to):

- Identifying, storing, and processing user and task profiling data (e.g. profiles held in local information service, central service profiles, or a mix of the two where local refines central)
- Identifying the subject of a user's search (e.g. user choice from a hierarchy, classification information in good local hits, or finding user input term in preferred or non-preferred terms in a locally or remotely held KOS)[12]
- Identifying information services with subject coverage relevant to a given user's subject search (e.g. Local list used for all; local list used for given user and task types; use of user and task profile and user subject to identify services in remote registry of information services classified according to subject coverage; user subject browse in a registry; use of a subject strength service)
- Identifying which KOS or KOS crosswalk service to use to identify the terms to use for the user's subject search in a given information using a given unknown KOS (e.g. Local data; service registry using KOS and user and task profile; using a terminology registry instead of a service registry)
- Describing, categorising, storing, serving up, and processing data about KOS and KOS crosswalking services (automated v intellectual; different spines or none, different levels of mapping granularity, etc) and handling it helpfully in a user interface based on its categorisation.
- Providing all of the above in different programming environments (and more) complete or well-structured. Through wide adoption of the requirements set outlined above, or of a similar set, it should be possible to promote progress towards greater subject interoperability in the networked world.

Conclusions: A Basis for Agreement?

As will be evident, the requirements set presented above is not a detailed and comprehensive specification, but, rather a proposal based on probable high-level attributes. Whether or not it can be a basis for an agreed collaborative approach re-

[12] *HILT Phase II identified one possible means of disambiguating a user's subject (see Nicholson et al, 2006) and implemented a limited version of a working mechanism (the pilot version could not deal with phrases, only single words, and a user could only choose one subject as relevant, not two or more as might sometimes be necessary). Other similar mechanisms are reported in Buckland 1999 and Doszkocs (1983)*

mains to be seen. However, it offers a useful focus for discussion and can provide a focus for a common research and development agenda as illustrated above. It may stimulate progress towards a requirements set that is widely acceptable.

Arguably, a joint approach to tackling the issues of subject interoperability would seem to offer a useful way forward.

Inset 5

Research suggested by the requirements set just described includes investigations into:

- The user characteristics that are relevant to profiling user types from a subject retrieval perspective and how best to categorise and express them for operational purposes
- The various retrieval tasks facing users and how best to categorise and express them for operational purposes
- How user and task profiles impact on retrieval requirements in a variety of contexts
- Mapping user input to subject in one or more standard schemes: determining what works best
- Using user's subject and user and task profiles to identify information services with subject coverage relevant to a user's subject search and their KOS
- Operational program-level requirements associated with KOS and KOS version identification and categorisation
- Using KOS and user and task profiles to identify appropriate KOS crosswalk services and their characteristics
- The relative effectiveness of a range of approaches to facilitating inter-KOS 'crosswalking' (automated v intellectual; different spines or none, different levels of mapping granularity, etc.)
- How distributed KOS/KOS crosswalk services utilising a range of different approaches and providing a range of different effectiveness levels can be described in a registry in such a way as to permit local user interfaces utilising M2M interaction to select, connect, and interact with each so as to best meet their users' needs
- The mechanics of requesting and obtaining interoperability data and using it with user and task profiles and interoperability service characteristics to facilitate subject interoperability
- Inter-KOS mapping issues, such as the range of mapping types needed for effective service and the usefulness or otherwise of providing user feedback on mapping types
- The different needs and perspectives in different communities (Archives v Libraries v Museums and others; information retrieval v semantic web)
- User interface design issues and user behaviour issues in relation to all of the above

It would permit the community to work together in a 'hands-off' but devolved and co-ordinated fashion. It would facilitate and expedite research and development through division of labour. It would reduce duplication of effort in respect of common mechanisms and research problems, and support an inclusive approach encouraging involvement across all interested domains.

Most important of all, perhaps, it would help ensure that each new KOS and KOS crosswalk service set up in one domain should enrich and extend the whole landscape, improving subject interoperability for all, as well as for those setting it up.

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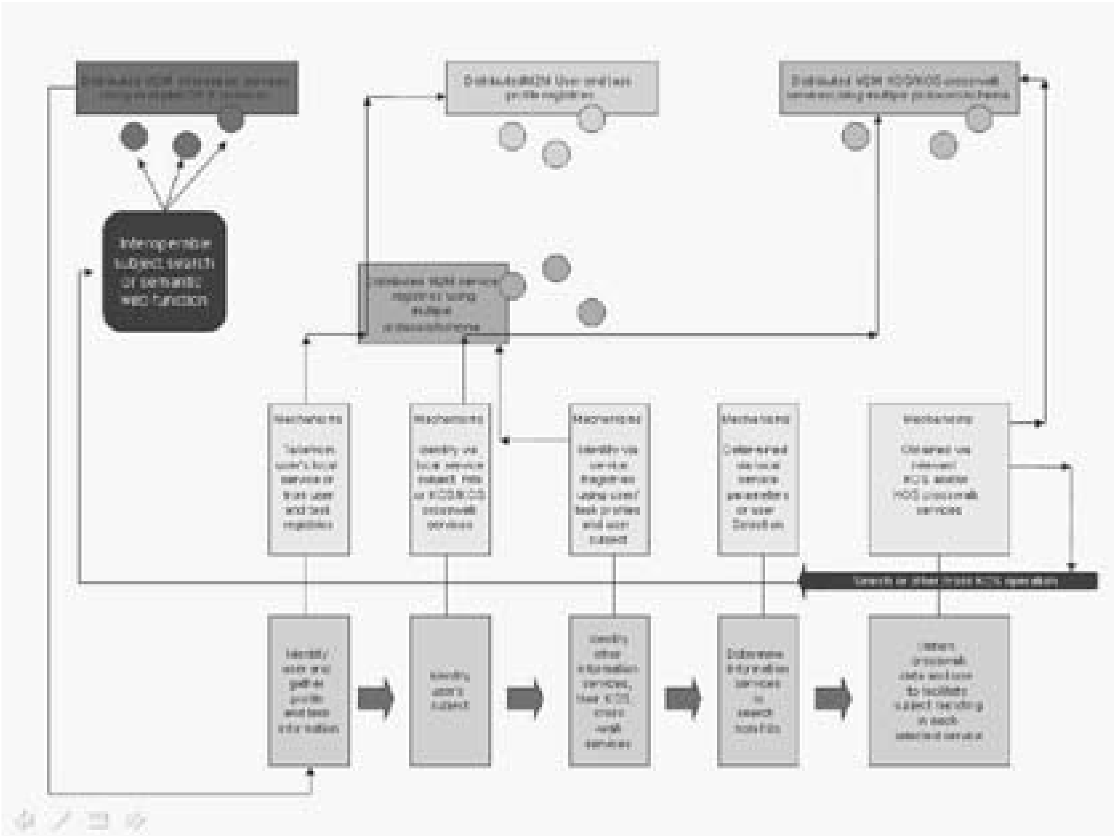
Inset 2



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